Gender differences in category-specificity do not reflect innate dispositions

Gerlach, Christian; Gainotti, Guido

Published in:
Cortex

DOI:
10.1016/j.cortex.2016.09.022

Publication date:
2016

Document version
Peer reviewed version

Document license
CC BY-NC-ND

Citation for pulished version (APA):
Gerlach, C., & Gainotti, G. (2016). Gender differences in category-specificity do not reflect innate dispositions. Cortex, 85, 46-53. DOI: 10.1016/j.cortex.2016.09.022

Gender differences in category-specificity do not reflect innate dispositions

RUNNING HEAD: Lack of innate gender differences in category-specificity

Christian Gerlach

Department of Psychology

University of Southern Denmark

Denmark

Guido Gainotti

Center for Neuropsychological Research and Department of Neurosciences

Institute of Neurology Policlinico Gemelli, Catholic University of Rome, Italy.

&

Department of Clinical and Behavioral Neurology,

IRCCS Fondazione Santa Lucia, Rome, Italy.

Address for correspondence:

Christian Gerlach, Department of Psychology, University of Southern Denmark, Campusvej 55, DK-5230 Odense M. Email: cgerlach@health.sdu.dk, Telephone: (+45) 65 50 28 17.

Word count

Abstract: 155 / Text: 3000

Abstract

It is well established that certain categories of objects are processed more efficiently than others in specific tasks; a phenomenon known as *category-specificity* in perceptual and conceptual processing. In the last two decades there have also been several reports of gender differences in category-specificity. In the present experiments we test the proposition that such gender differences have an evolutionary origin. If they do, we would expect them to emerge even when the population tested comprises young individuals raised in a gender-equality oriented society. Contrary to this expectation we find no evidence of gender differences in category-specificity in a relatively large sample (N = 366) drawn from such a population; and this despite the fact that both tasks applied (object decision and superordinate categorization) gave rise to reliable category-effects. We suggest that a plausible account of this discrepancy is that previous reports of gender differences may have reflected differences in familiarity originating from socially-based gender roles.

Keywords: Category-effects; Evolution; Gender differences; Semantics; Visual object processing.

1. Introduction

The functional organization of conceptual knowledge has been a central topic in cognitive neuroscience since Warrington in 1975 described the first cases of selective semantic impairments in patients with brain injury. This report was followed by neuropsychological studies suggesting that semantic memory could even be affected in a category-specific manner, so that comprehension of artefacts could be relatively preserved compared with comprehension of biological entities or vice versa (e.g., Hillis & Caramazza, 1991; Sartori & Job, 1988; Silveri & Gainotti, 1988; Warrington & McCarthy, 1983; Warrington & McCarthy, 1987; Warrington & Shallice, 1984; for reviews see Capitani, Laiacona, Mahon, & Caramazza, 2003; Gainotti, 2000). Furthermore, ensuing investigations showed that within the broad class of biological objects semantic disorders can selectively disrupt the comprehension of fruits and vegetables (e.g., Forde, Francis, Riddoch, Humphreys, 1997; Hart, Berndt, & Caramazza, 1985; Samson & Pillon, 2003; for reviews see Capitani et al., 2009; Gainotti, 2005, 2010) or animals (e.g., Caramazza & Shelton, 1998; Hart & Gordon, 1992; for reviews see Capitani et al., 2009; Gainotti, 2005).

While the existence of category-specific disorders is well established, there is no consensus regarding their explanation (Gainotti, 2015). Indeed, there seem to be two general positions with a respectively Platonic and Aristotelian legacy; the rationalistic position which stresses that category-specific impairments basically reflects innate constraints on conceptual knowledge, and the empiricist position, which stresses that category-specific impairments stem from the fact that the organization of knowledge is a product of experience. The main proponents of an innate position are Caramazza and Shelton (1998) who proposed "…that evolutionary pressures have resulted in specialized mechanisms for perceptually *and* conceptually distinguishing animate and inanimate kinds …, leading to a *categorical* organization of this knowledge in the brain" (p. 9). More specifically, these authors suggested that dedicated neural mechanisms, developed under

evolutionary pressure, could subserve different 'domains of knowledge', which play a very important role in human survival. These domains of knowledge could concern 'animals' (potential predators), 'plant life' (possible source of foods and medicine), 'body parts' and 'artefacts'. On the other hand, the empiristic position, which can be considered as a development of the 'differential weighting hypothesis', proposed by Warrington and McCarthy (1983) and Warrington & Shallice (1984), maintains that different kinds of sensory-motor and functional sources of knowledge could play different roles in the comprehension of various kinds of living and non-living categories. These theoretical accounts of category-specificity were further developed by Mahon and Caramazza (2011), and by Chen and Rogers (2014). The former argued that there are innately determined patterns of connectivity that mediate the integration of information from the ventral stream with information computed by other brain regions and that the specialization by semantic category in the ventral stream is driven by that connectivity. The latter reviewed evidence supporting the view that category-specificity arises from many heterogeneous factors, and that apparent category-specific patterns cannot be interpreted on the basis of the Warrington & Shallice's (1984) sensory/functional theory, but actually reflect differential reliance on different kinds of sensory, motor, linguistic, and affective information (e.g., Gainotti, Spinelli, Scaricamazza, & Marra, 2013a; Hoffman & Lambon Ralph, 2013). According to this view, category-specificity should tell us little directly about the cognitive and neural architecture of semantic memory.

Entwined with the controversy regarding whether the organization of conceptual knowledge is primarily a product of nature or nurture is the issue of gender differences in category-specificity. Theoretically, it must be admitted that if the organization of conceptual knowledge is a product of innate constraints, and if evolution has led to gender differences in division of labor related to these constraints (Laiacona, Barbarotto, & Capitani, 2006; Silverman & Eals, 1992), it seems reasonable to expect gender differences in conceptual processing of certain categories of objects. Also, from a

factual standpoint, both data from category-specific semantic disorders and from experimental investigations in healthy subjects suggest, indeed, an interaction between gender and category-specificity. Results obtained in patients with category-specific semantic disorders have been summarized by Gainotti (2005), who showed that in patients with category-specific impairments for biological entities, men were systematically more impaired with plant life categories and women were usually more impaired with animals. Data obtained in healthy subjects are generally consistent with those observed in patients with category-specific disorders, because they have shown that men are more familiar, and obtain better performances, with artefacts and animals, whereas women are more familiar and proficient with fruits and vegetables. We briefly describe these findings below, limiting the scope to those reported with neurologically intact subjects, as this is the main topic of the present paper.

Gender-related asymmetries in category-specificity have been observed in naming tasks from adults and children (McKenna & Parry, 1994), in familiarity ratings (Albanese, Capitani, Barbarotto, & Laiacona, 2000), and in age of acquisition of common names (Barbarotto, Laiacona, & Capitani, 2008). Similar asymmetries have been found on speeded naming (Laws, 1999) and identification (Laws, 2000) tasks, on name-generation tasks (Laws, 2004), on semantic fluency tasks (Cameron, Wambaugh, & Mauszycki, 2008; Capitani, Laiacona, & Barbarotto, 1999; Marra, Ferraccioli, & Gainotti, 2007), and on object decision tasks (Barbarotto, Laiacona, Macchi, & Capitani, 2002). As for the gender-related differences in processing of biological vs. artefact categories, most authors (e.g., Barbarotto et al., 2008; Capitani et al., 1999; Laws, 1999, 2000, 2004) report that males are more proficient with artefacts, and females with biological stimuli. Laws (1999), for instance, reported a significant interaction between gender and category in picture naming with males being faster at naming non-living things, and females being faster at naming living things. A similar pattern was found in a picture-naming task using a naming-to-deadline

paradigm (Laws, 2000), and by Barbarotto et al. (2008) who found a male advantage for naming 'Tools' and a female advantage for naming 'Fruit'. As for the investigations of male and female performance *within* the biological categories, several studies have shown that men are more proficient with 'animals' and women with 'fruit' and 'vegetables' (Albanese et al., 2000; Barbarotto et al., 2002; Cameron et al., 2008; Capitani et al., 1999; Laws, 2004; McKenna & Parry, 1994; Moreno-Martinez, Laws, & Schulz, 2008).

An 'innate' interpretation of the gender asymmetries was offered by Laws (2000, 2004) who suggested that a greater development of brain circuits dealing with tools and animals in men, and with fruits and vegetables in women, could be a product of the main subsistence activities of men (hunting) and women (gathering). Refining this line of thought, Laiacona et al. (2006), proposed that the evolutionary pressures, which prompted the development of different brain networks dedicated to animals and plant life, might also have provided each gender with more efficient cognitive representations of their main foraging targets (i.e. animals for men and fruits and vegetables for women). A different, and experience-dependent, interpretation of gender asymmetries was proposed by Gainotti (2005, 2010). He suggested that only the distinction between living and non-living things reflects an inborn anatomically-based categorical organization, whereas the asymmetry (within living entities) between animals and plant life might be due to familiarity factors related to social roles, namely to men's greater familiarity with animals and women's with fruits and vegetables. The hypothesis that gender asymmetries may be experience-dependent is supported by the dissociations observed within the artefact categories, in which men are more proficient with 'tools' and women with 'furniture' and 'kitchen utensils' (Albanese et al., 2000; Barbarotto et al., 2002; Moreno-Martinez et al., 2008). In apparent contrast with the existence of gender asymmetries in categorical tasks are results obtained in young men and women by Moreno-Martinez et al. (2008), studying semantic fluency on different subcategories of living and non-living

things, and by Gainotti, Ciaraffa, Silveri and Marra (2010), assessing their familiarity with different 'biological' and 'artefact' categories. No difference was observed in these studies between young males and females on any of the categories examined. These unexpected results could, however, be due to the fact that young men and women included in the studies of Moreno-Martinez et al. (2008) and of Gainotti et al. (2010) were undergraduate students, belonging to a generation in which the traditional social roles have almost completely disappeared. If so, these negative findings are still in keeping with an experience-based account.

Even if gender differences reflect differences in familiarity originating from socially based gender roles, one may enquire where these socially based gender roles come from to begin with. Could it not be the case, as implied by Laws (2000, 2004) and by Laiacona et al. (2006), that socially determined gender roles, which may cause males and females to gain more familiarity with some categories of objects than others, do in fact have an evolutionary origin? This possibility seems hard to dismiss, but a strong case against such proposition would be to show that gender differences do not exist in cultures where males and females are treated equally (or where such an ideology is at least considered an objective).

To address this issue we examined visual object processing performance in a relatively large sample (N = 366) of young adults with a relatively homogenous background from an allegedly gender-equality oriented country (Denmark). We subjected this group to two tasks which have previously been shown to produce reliable category-effects in neurologically intact subjects: Difficult object decision and superordinate categorization (Gerlach, 2009; Gerlach & Marques, 2014). Should we fail to observe category-specific gender differences in these tasks, we will consider it unlikely that previous reports of gender differences reflect innate dispositions.

2. Method

2.1. Participants

366 subjects participated (mean age 23, SD = 6, range 18-56 years, 266 females). The participants were first-year students in the psychology programme at the University of Southern Denmark naïve to the purpose of the experiment.

2.2. Design

Each participant first performed the superordinate categorization and was instructed to press the 'M-key' for artefacts and the 'N-key' for biological entities. In the object decision task the subjects used the 'M-key' for real objects and the 'N-key' for nonobjects. The participants were encouraged to respond as fast and as accurately as possible. Prior to each task the participant performed a practice version of the upcoming task. Stimuli used in these practice versions were not used in the actual experimental conditions.

2.3. Stimuli

80 pictures were presented in the categorization task. These pictures were taken from the set by Snodgrass and Vanderwart (1980) and consisted of 40 biological entities and 40 artefacts (see the appendix). These two sets of objects did not differ significantly in familiarity, visual complexity, and image agreement (Mann-Whitney, $p > .05$).

160 pictures were presented in the object decision task: 80 real objects and 80 chimeric nonobjects. The real objects were the same as used in the categorization task. The 80 nonobjects

were line-drawings of closed figures constructed by exchanging single parts belonging to objects from the same category (see Figure 1). The order of pictures was randomized in each task.

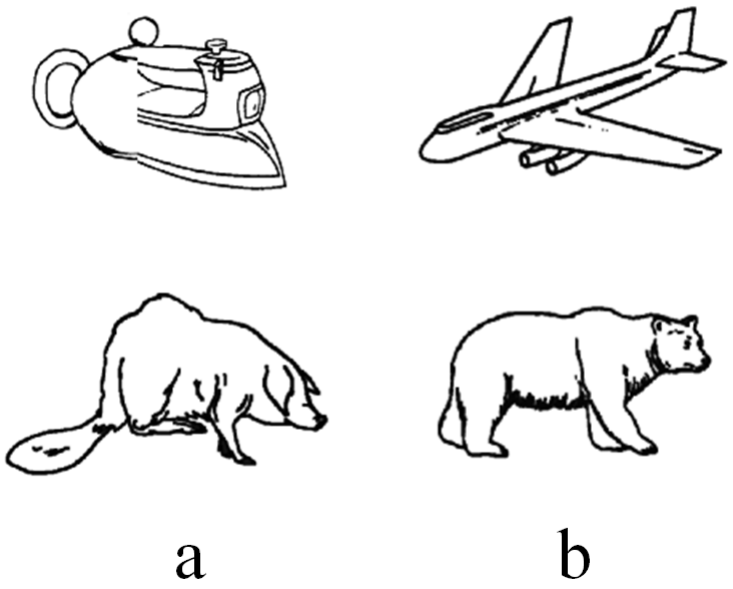

Figure 1. Examples of stimuli used in the object decision task. (a) Chimeric nonobjects, and (b) real objects. The real objects were also used in the superordinate categorization task.

2.4. Procedure

All stimuli were presented centrally on a white background on a PC-monitor and subtended 3-5 degrees of visual angle. The stimuli were displayed until the participant made a response. The interval between response and presentation of the next object was 1 s. RTs were recorded by means of the keyboard.

2.5. Statistical analysis

All analyses presented below are based on correct responses to *real* objects only. Likewise, error rates are also based on responses to *real* objects only. Given that exactly the same real objects were presented in the object decision task and the categorization task this makes RTs and error rates directly comparable across tasks.

In the first series of analyses, we examined effects of category. These analyses were included because a failure to find category-effects with the present tasks could call into question their sensitivity and hence suitability to detect gender differences in category-effects.

In the second series of analyses we examined effects of gender on processing of biological items and artefacts. In the third and last series of analyses, we examined effects of gender for subcategories of biological entities and artefacts. This was done by regrouping biological entities into the subcategories: 'Animals' and 'Vegetables/Fruit', and artefacts into the subcategories: 'Manipulable artefacts' (handheld objects) and 'Less-manipulable artefacts' (not handheld objects). The motivation for this was to align our analyses as closely as possible with previous studies which had contrasted for example 'Praxic' vs. 'Non-praxic' artefacts (McKenna & Parry, 1994) or 'Tools' vs. 'Vehicles'. As not all items could be regrouped into these subcategories, the subcategories differed in size. The subcategory 'Animals' comprised 26 items, 'Vegetables/Fruit' 13 items, 'Manipulable artefacts' 19 items, and 'Less-manipulable artefacts' 12 items. See the appendix for a full list of the real items used and how they were indexed category-wise. The subgroup of 'Manipulable artefacts' was reliably more manipulable than the subgroup of 'Less-manipulable artefacts' according to the norms by Magnié, Besson, Poncet, and Dolisi, 2003 (M_{dif} = 1.53, CI 95% [.99, 2.06]).

The data-analyses presented are based on confidence intervals (CI) and their degree of overlap (Cumming, 2014), and the CIs reported are bias corrected accelerated bootstrap-estimates based on 2000 samples.

3. Results

3.1. Effects of category

3.1.1. Accuracy

The mean number of correct responses was reliably higher for artefacts than for biological entities in both the object decision task (M_{dif} = 0.4, CI 95% [.2, .7]; d_z = .2) and the categorization task (M_{dif} = 0.4, CI 95% [.2, .5]; d_z = .28); see Table 1.

- Insert Table 1 near here -

3.1.2. RT

The mean correct RT was reliably longer for biological entities than for artefacts in the object decision task (M_{dif} = 42, CI 95% [33, 52]; d_z = .47) but reliably longer for artefacts than for biological entities in the categorization task (M_{dif} = 49, CI 95% [41, 56]; d_z = .69): see Table 1.

3.2. Effects of gender I (Biological entities & Artefacts).

3.2.1. Accuracy

The only reliable gender difference found was that females produced more correct responses than males to artefacts in the categorization task (M_{dif} = .24, CI 95% [.02, .47]; d = .25), see Table 1 and Figure 2.

3.2.1. RT

There were no reliable gender differences in terms of RT for artefacts or biological items in any of the tasks; see Table 1.

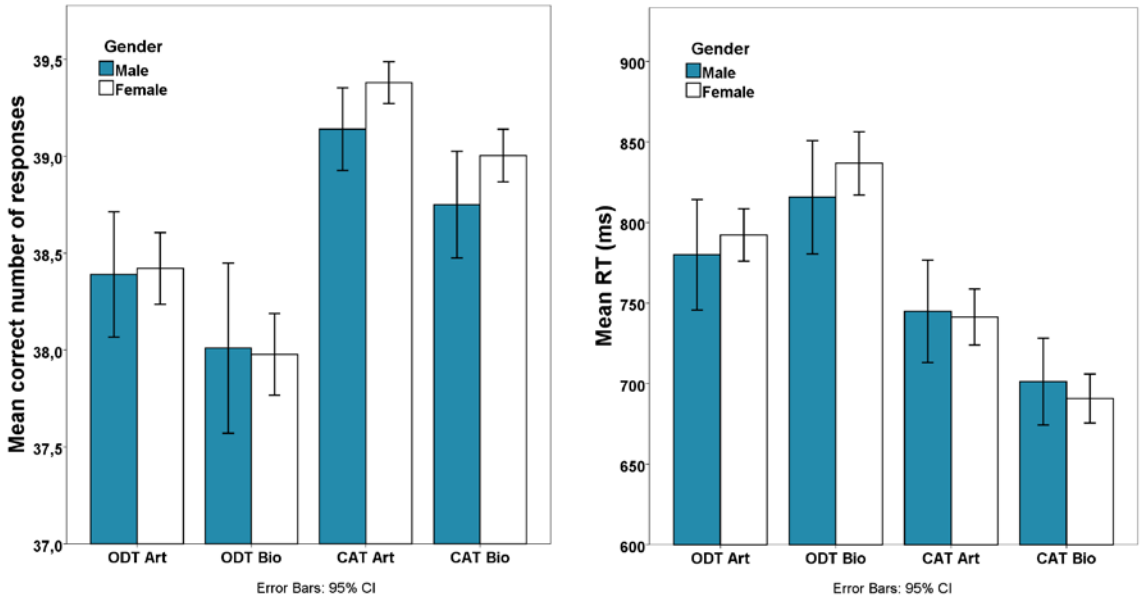

Figure 2. Mean number of correct responses (left panel) and mean RT (right panel) to real objects presented in the object decision task and the superordinate categorization task as function of category and gender. Error bars represent the 95% confident intervals of the means. ODT = Object decision task; CAT = Categorization task; Art = Artefacts; Bio = Biological entities.

3.3. Effects of gender II (Animals, Vegetables/Fruit, Manipulable artefacts & Less-manipulable artefacts).

3.3.1. Accuracy

There were no reliable gender differences in terms of accuracy for any of the four categories in any of the tasks; see Table 2 and Figure 3.

- Insert Table 2 near here -

3.3.2. RT

There were no reliable gender differences in terms of RT for any of the four categories in any of the tasks; see Table 2 and Figure 3.

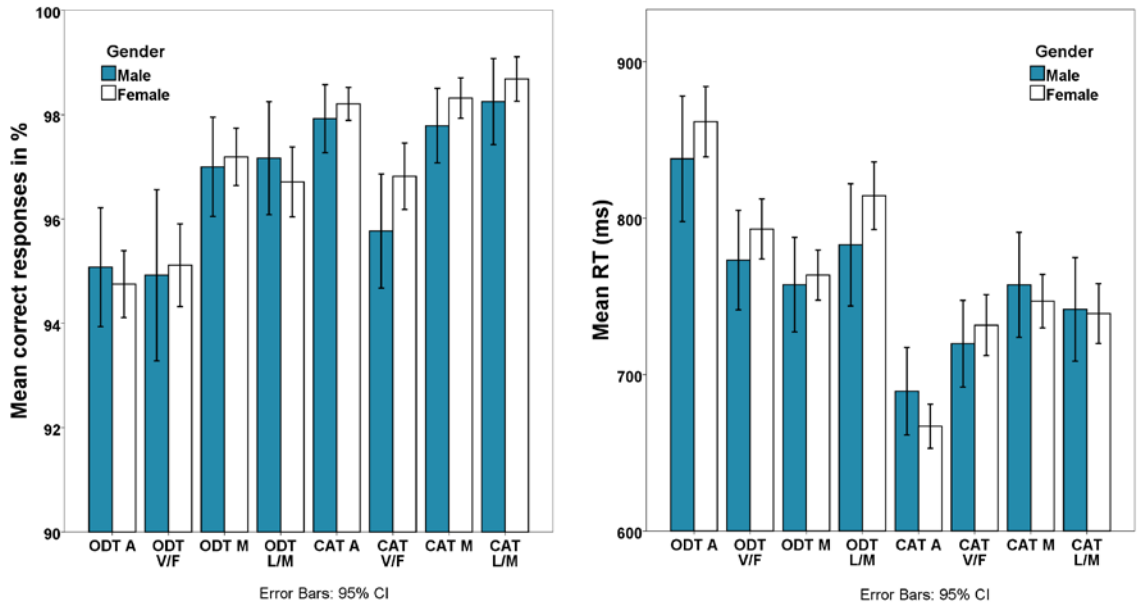

Figure 3. Mean correct responses in percent (left panel) and mean RT (right panel) to real objects presented in the object decision task and the superordinate categorization task as function of category and gender. Error bars represent the 95% confident intervals of the means. ODT = Object decision task; CAT = Categorization task; A = animals; V/F = Vegetables/Fruit; M = Manipulable artefacts; L/M = Less manipulable artefacts.

4. Discussion

We find reliable category-effects in the applied tasks; RTs were slower for biological items than for artefacts in object decision (d = .47), but faster for biological entities than for artefacts in

superordinate categorization (d = .69). These findings are similar to what has been found in previous studies using these tasks (Gerlach, 2009; Gerlach & Marques, 2014), and prove that they are sensitive to category-effects. Despite the sensitive nature of the tasks, we find little evidence of gender differences in the processing of the examined categories. In fact, the only reliable effect found was that females made fewer errors than males when categorizing artefacts. The effect was small (d = .25) and went in the opposite direction of previous findings (Barbarotto et al., 2002; Laiacona, Barbarotto, & Capitani, 1998; Laws, 1999, 2000). Moreover, females in general exhibited a tendency for better performance than males with all categories during the categorization task; both when considering the broad classes of biological entities and artefacts but also when these broad classes were broken down in subcategories ('Animals', 'Vegetables/Fruit', 'Manipulable artefacts', and 'Less-manipulable artefacts'). Accordingly, the small but reliable female advantage found for the broad class of artefacts during categorization seems more task- than category-related.

In summary, the main result of the present investigation is that no category-specific gender effect is found in our sample irrespectively of: (i) the nature of the task (object decision or categorization), (ii) the category contrasts performed ('Biological entities', 'Artefacts', or 'Animals', 'Vegetables/Fruit', 'Manipulable artefacts', and 'Less-manipulable artefacts'), and (iii) the dependent measure used (accuracy or RT). Regardless of this, one may still be concerned that the null-findings reflect Type II errors. From a theoretical point of view, however, the sample size of the current study should allow for a small to moderate effect (d > .42) to be detected with a probability of .95 (β-level) at an α-level of .05 (Faul, Erdfelder, Lang, & Buchner, 2007). In practice, the present study was sensitive enough to detect a gender difference corresponding to d = .25 (it just happened to go in the opposite direction of what has been found previously).

If gender-related differences in category-specificity reflect innate constraints, as suggested by Laws (2000, 2004) and Laiacona et al. (2006), we would expect such differences to manifest

themselves even in a population of young subjects raised in a gender-equality oriented society. The fact that we find no gender differences in such a population is problematic for an evolutionary based account.

There may of course be several reasons for the discrepancy between the present and previous findings including differences in the applied tasks and stimuli. Explanations cast along these lines would, however, not be less problematic for an evolutionary account as it does not specify that gender effects should be context-dependent. Such context-dependency calls for a more flexible account. One such account, which is clearly compatible with our results, is that gender differences may reflect differences in familiarity originating from socially-based gender roles, as suggested by Moreno-Martinez et al. (2008) and Gainotti, Spinelli, Scaricamazza, and Marra (2013b).

Hence, even though the present findings do not directly demonstrate, but are merely compatible with the proposal that gender asymmetries reflect social-role related factors, they do show that an interpretation of gender asymmetries based on the same principles which have prompted the general innate position (Caramazza & Mahon, 2006; Caramazza & Shelton, 1998; Mahon & Caramazza, 2003) is not tenable.

Acknowledgments

The first author wishes to pay his gratitude to the Friends of Fakutsi Association (FFA), Thomas W. Teasdale, and for Julia Emma Robotham’s advice.

Role of the funding source

This work was supported by a grant from the Danish Research Council for the Humanities to the first author (DFF – 4001-00115). This funding agency had no role in designing or conducting the study, in writing the report, or in deciding to submit the paper for publication.

References

Albanese, E., Capitani, E., Barbarotto, R., & Laiacona, M. (2000). Semantic Category Dissociations, Familiarity and Gender. *Cortex, 36*(5), 733-746. doi:http://dx.doi.org/10.1016/S0010-9452(08)70549-5

Barbarotto, R., Laiacona, M., & Capitani, E. (2008). Does sex influence the age of acquisition of common names? A contrast of different semantic categories. *Cortex, 44*(9), 1161-1170. doi:10.1016/j.cortex.2007.08.016

Barbarotto, R., Laiacona, M., Macchi, V., & Capitani, E. (2002). Picture reality decision, semantic categories and gender: A new set of pictures, with norms and an experimental study. *Neuropsychologia, 40*(10), 1637-1653. doi:http://dx.doi.org/10.1016/S0028-3932(02)00029-5

Cameron, R. M., Wambaugh, J. L., & Mauszycki, S. (2008). Effects of age, gender, and education on semantic fluency for living and artifact categories. *Aphasiology, 22*(7-8), 790-801. doi:10.1080/02687030701818018

Capitani, E., Laiacona, M., & Barbarotto, R. (1999). Gender Affects Word Retrieval of Certain Categories in Semantic Fluency Tasks. *Cortex, 35*(2), 273-278. doi:http://dx.doi.org/10.1016/S0010-9452(08)70800-1

Capitani, E., Laiacona, M., Mahon, B., & Caramazza, A. (2003). What are the facts of semantic category-specific deficits? A critical review of the clinical evidence. *Cogn Neuropsychol, 20*(3), 213-261. doi:10.1080/02643290244000266

Capitani, E., Laiacona, M., Pagani, R., Capasso, R., Zampetti, P., & Miceli, G. (2009). Posterior cerebral artery infarcts and semantic category dissociations: a study of 28 patients. *Brain, 132*(Pt 4), 965-981. doi:10.1093/brain/awp013

Caramazza, A., & Mahon, B. Z. (2006). The organisation of conceptual knowledge in the brain: The future's past and some future directions. *Cogn Neuropsychol, 23*(1), 13-38. doi:10.1080/02643290542000021

Caramazza, A., & Shelton, J. R. (1998). Domain-specific knowledge systems in the brain the animate-inanimate distinction. *J Cogn Neurosci, 10*(1), 1-34.

Chen, L., & Rogers, T. T. (2014). Revisiting domain-general accounts of category specificity in mind and brain. *WIREs Cogn Sci, 5*(3), 327-344. DOI: 10.1002/wcs.1283.

Cumming, G. (2014). The new statistics: why and how. *Psychol Sci, 25*(1), 7-29. doi:10.1177/0956797613504966

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175-191.

Forde, E. M. E., Francis, D., Riddoch, M. J., Humphreys, R. I. R., & G.W. (1997). On the Links between Visual Knowledge and Naming: a Single Case Study of a Patient with a Category-specific Impairment for Living Things. *Cognitive Neuropsychology, 14*(3), 403-458. doi:10.1080/026432997381538

Gainotti, G. (2000). What the locus of brain lesion tells us about the nature of the cognitive defect underlying category-specific disorders: a review. *Cortex, 36*(4), 539-559.

Gainotti, G. (2005). The influence of gender and lesion location on naming disorders for animals, plants and artefacts. *Neuropsychologia, 43*(11), 1633-1644. doi:10.1016/j.neuropsychologia.2005.01.016

Gainotti, G. (2010). The influence of anatomical locus of lesion and of gender-related familiarity factors in category-specific semantic disorders for animals, fruits and vegetables: a review of single-case studies. *Cortex, 46*(9), 1072-1087. doi:10.1016/j.cortex.2010.04.002

Gainotti, G. (2015). Inborn and experience-dependent models of categorical brain organization. A position paper. *Front Hum Neurosci, 9*, 2. doi:10.3389/fnhum.2015.00002

Gainotti, G., Ciaraffa, F., Silveri, M. C., & Marra, C. (2010). Different views about the nature of gender-related asymmetries in tasks based on biological or artefact categories. *Behav Neurol, 22*(3-4), 81-90. doi:10.3233/ben-2009-0247

Gainotti, G., Spinelli, P., Scaricamazza, E., & Marra, C. (2013a). The evaluation of sources of knowledge underlying different semantic categories. *Front. Hum. Neurosci.*, 21 February 2013 doi: 10.3389/fnhum.2013.00040.

Gainotti, G., Spinelli, P., Scaricamazza, E., & Marra, C. (2013b). Asymmetries in gender-related familiarity with different semantic categories. Data from normal adults. *Behav Neurol, 27*(2), 175-181. doi:10.3233/ben-120277

Gerlach, C. (2009). Category-specificity in visual object recognition. *Cognition, 111*(3), 281-301. doi:10.1016/j.cognition.2009.02.005

Gerlach, C., & Marques, J. F. (2014). Visual complexity exerts opposing effects on object categorization and identification. *Visual Cognition, 22*(6), 751-769. doi:10.1080/13506285.2014.915908

Hart, J., Jr., Berndt, R. S., & Caramazza, A. (1985). Category-specific naming deficit following cerebral infarction. *Nature, 316*(6027), 439-440.

Hart, J., Jr., & Gordon, B. (1992). Neural subsystems for object knowledge. *Nature, 359*(6390), 60-64. doi:10.1038/359060a0

Hillis, A. E., & Caramazza, A. (1991). Category-specific naming and comprehension impairment: a double dissociation. *Brain, 114 (Pt 5)*, 2081-2094.

Hoffman, P., & Lambon Ralph, M. A. (2013). Shapes, scents and sounds: quantifying the full multi-sensory basis of conceptual knowledge. *Neuropsychologia 51*(1), 14-25 doi: 10.1016/j.tics.2011.01.004.

Laiacona, M., Barbarotto, R., & Capitani, E. (1998). Semantic category dissociations in naming: is there a gender effect in Alzheimer's disease? *Neuropsychologia, 36*(5), 407-419.

Laiacona, M., Barbarotto, R., & Capitani, E. (2006). Human evolution and the brain representation of semantic knowledge: is there a role for sex differences? *Evolution and Human Behavior, 27*(2), 158-168. doi:http://dx.doi.org/10.1016/j.evolhumbehav.2005.08.002

Laws, K. R. (1999). Gender Affects Naming Latencies for Living and Nonliving Things: Implications for Familiarity. *Cortex, 35*(5), 729-733. doi:http://dx.doi.org/10.1016/S0010-9452(08)70831-1

Laws, K. R. (2000). Category-Specific Naming Errors in Normal Subjects: The Influence of Evolution and Experience. *Brain Lang, 75*(1), 123-133. doi:http://dx.doi.org/10.1006/brln.2000.2348

Laws, K. R. (2004). Sex differences in lexical size across semantic categories. *Personality and Individual Differences, 36*(1), 23-32. doi:http://dx.doi.org/10.1016/S0191-8869(03)00048-5

Magnie, M. N., Besson, M., Poncet, M., & Dolisi, C. (2003). The Snodgrass and Vanderwart set revisited: norms for object manipulability and for pictorial ambiguity of objects, chimeric objects, and nonobjects. *J Clin Exp Neuropsychol, 25*(4), 521-560. doi:10.1076/jcen.25.4.521.13873

Mahon, B. Z., & Caramazza, A. (2003). Constraining questions about the organisation and representation of conceptual knowledge. *Cogn Neuropsychol, 20*(3), 433-450. doi:10.1080/02643290342000014

Mahon, B. Z., & Caramazza, A. (2011). What drives the organization of object knowledge in the brain? *Trends Cogn Sci. 15*(3), 97-103. doi: 10.1016/j.tics.2011.01.004.

Marra, C., Ferraccioli, M., & Gainotti, G. (2007). Gender-related dissociations of categorical fluency in normal subjects and in subjects with Alzheimer's disease. *Neuropsychology, 21*(2), 207-211. doi:10.1037/0894-4105.21.2.207

McKenna, P., & Parry, R. (1994). Category specificity in the naming of natural and man-made objects: Normative data from adults and children. *Neuropsychological Rehabilitation, 4*(3), 255-281. doi:10.1080/09602019408401461

Moreno-Martinez, F. J., Laws, K. R., & Schulz, J. (2008). The impact of dementia, age and sex on category fluency: greater deficits in women with Alzheimer's disease. *Cortex, 44*(9), 1256-1264. doi:10.1016/j.cortex.2007.11.008

Samson, D., & Pillon, A. (2003). A case of impaired knowledge for fruit and vegetables. *Cogn Neuropsychol, 20*(3), 373-400. doi:10.1080/02643290244000329

Sartori, G., & Job, R. (1988). The oyster with four legs: A neuropsychological study on the interaction of visual and semantic information. *Cognitive Neuropsychology, 5*(1), 105-132. doi:10.1080/02643298808252928

Silveri, M. C., & Gainotti, G. (1988). Interaction between vision and language in category-specific semantic impairment. *Cognitive Neuropsychology, 5*(6), 677-709. doi:10.1080/02643298808253278

Silverman, I., & Eals, M. (1992). Sex differences in spatial abilities: Evolutionary theory and data. In J. H. Barkow, L. Cosmides, & J. Tooby (Eds.), *The adapted mind: Evolutionary psychology and the generation of culture* (pp. 533-549). New York, NY, US: Oxford University Press.

Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: norms for name agreement, image agreement, familiarity, and visual complexity. *J Exp Psychol Hum Learn, 6*(2), 174-215.

Warrington, E. K. (1975). The selective impairment of semantic memory. *Q J Exp Psychol, 27*(4), 635-657. doi:10.1080/14640747508400525

Warrington, E. K., & McCarthy, R. (1983). Category specific access dysphasia. *Brain, 106 (Pt 4)*, 859-878.

Warrington, E. K., & McCarthy, R. A. (1987). Categories of knowledge. Further fractionations and an attempted integration. *Brain, 110 (Pt 5)*, 1273-1296.

Warrington, E. K., & Shallice, T. (1984). Category specific semantic impairments. *Brain, 107 (Pt 3)*, 829-854.

Figure captions

Figure 1. Examples of stimuli used in the object decision task. (a) Chimeric nonobjects, and (b) real objects. The real objects were also used in the superordinate categorization task.

Figure 2. Mean number of correct responses (left panel) and mean RT (right panel) to real objects presented in the object decision task and the superordinate categorization task as function of category and gender. Error bars represent the 95% confident intervals of the means. ODT = Object decision task; CAT = Categorization task; Art = Artefacts; Bio = Biological entities.

Figure 3. Mean correct responses in percent (left panel) and mean RT (right panel) to real objects presented in the object decision task and the superordinate categorization task as function of category and gender. Error bars represent the 95% confident intervals of the means. ODT = Object decision task; CAT = Categorization task; A = animals; V/F = Vegetables/Fruit; M = Manipulable artefacts; L/M = Less manipulable artefacts.

Appendix

Biological items		Artefacts	
Item	Subcategory	Item	Subcategory
Ant	Animal	Airplane	Less-manipulable
Apple	Vegetable/Fruit	Anchor	Less-manipulable
Artichoke	Vegetable/Fruit	Barn	Less-manipulable
Banana	Vegetable/Fruit	Barrel	Less-manipulable
Bear	Animal	Baseball bat	Manipulable
Bee	Animal	Bell	
Beetle	Animal	Bow	
Bird	Animal	Bowl	Manipulable
Camel	Animal	Cannon	Less-manipulable
Carrot	Vegetable/Fruit	Cigar	Manipulable
Cherry	Vegetable/Fruit	Clock	Less-manipulable
Deer	Animal	Crown	
Dog	Animal	Envelope	Manipulable
Duck	Animal	French horn	Manipulable
Eagle	Animal	Glove	Manipulable
Fish	Animal	Gun	Manipulable
Fox	Animal	Hammer	Manipulable
Gorilla	Animal	Harp	Manipulable
Grapes	Vegetable/Fruit	Hat	
Kangaroo	Animal	Iron	Manipulable
Lemon	Vegetable/Fruit	Jacket	
Lion	Animal	Motorcycle	Less-manipulable
Monkey	Animal	Nut	Manipulable
Mushroom	Vegetable/Fruit	Pen	Manipulable

Onion	Vegetable/Fruit	Record player	
Ostrich	Animal	Roller skate	
Owl	Animal	Rolling pin	Manipulable
Pear	Vegetable/Fruit	Ruler	Manipulable
Penguin	Animal	Sailboat	Less-manipulable
Rooster	Animal	Sled	Less-manipulable
Sea horse	Animal	Spinning wheel	
Seal	Animal	Stool	
Sheep	Animal	Suitcase	Manipulable
Snail	Animal	Thimble	Manipulable
Spider	Animal	Umbrella	Manipulable
Strawberry	Vegetable/Fruit	Watch	Manipulable
Swan	Animal	Well	Less-manipulable
Tomato	Vegetable/Fruit	Wheel	Less-manipulable
Tree		Whistle	Manipulable
Watermelon	Vegetable/Fruit	Windmill	Less-manipulable

	Image agreement	Familiarity	Visual Complexity
Animals	M = 3.9, SD = .55	M = 3.2, SD = .89	M = 2.8, SD = .91
Vegetables/Fruit	M = 3.6, SD = .65	M = 2.5, SD = .94	M = 3.5, SD = .75
Manipulable	M = 3.4, SD = .49	M = 2.3, SD = .70	M = 3.7, SD = .47
Less-manipulable	M = 4.0, SD = .50	M = 3.4, SD = .55	M = 2.5, SD = .87

Table 1. The mean number of correct responses (max = 40), mean correct RTs (ms) and 95% CIs [in brackets] associated with artefacts and natural objects in the object decision task and the categorization task

	Males/ & Females		Males		Females	
	Accuracy	RT	Accuracy	RT	Accuracy	RT
Object decision artefacts	38.4 [38.2, 38.6]	789 [774, 803]	38.4 [38.1, 38.7]	780 [748, 817]	38.4 [38.2, 38.6]	792 [776, 809]
Object decision natural objects	38.0 [37.8, 38.2]	831 [814, 847]	38.0 [37.5, 38.4]	816 [784, 849]	38.0 [37.8, 38.2]	837 [819, 854]
Categorization artefacts	39.3 [39.2, 39.4]	742 [727, 757]	39.1 [38.9, 39.3]	745 [717, 774]	39.4 [39.3, 39.5]	741 [725, 758]
Categorization natural objects	38.9 [38.8, 39.1]	694 [679, 707]	38.8 [38.5, 39.0]	701 [676, 728]	39.0 [38.9, 39.1]	691 [676, 706]

Table 2. The mean percentage correct responses, mean correct RTs (ms) and 95% CIs [in brackets] associated with the subcategories 'Animals', 'Vegetables/fruit', Manipulable artefacts', and 'Less-manipulable artefacts' in the object decision task and the categorization task

	Males		Females	
	Accuracy (%)	RT	Accuracy (%)	RT
Object decision 'Animals'	95.1 [93.9, 96.2]	838 [800, 878]	94.8 [94.1, 95.4]	862 [841, 885]
Object decision 'Vegetables/fruit'	94.9 [93.1, 96.5]	773 [743, 803]	95.1 [94.3, 95.9]	793 [775, 812]
Object decision 'Manipulable artefacts'	97.0 [96.0, 97.9]	757 [727, 790]	97.2 [96.6, 97.8]	764 [749, 779]
Object decision 'Less-manipulable artefacts'	97.2 [95.9, 98.2]	783 [751, 819]	96.7 [96.0, 97.3]	814 [794, 837]
Categorization 'Animals'	97.9 [97.2, 98.7]	689 [663, 719]	98.2 [97.9, 98.5]	667 [652, 682]
Categorization 'Vegetables/fruit'	95.8 [94.6, 96.9]	720 [693, 748]	96.8 [96.2, 97.5]	732 [712, 751]
Categorization 'Manipulable artefacts'	97.8 [97.0, 98.5]	757 [727, 789]	98.3 [97.9, 98.7]	747 [730, 765]
Categorization 'Less-manipulable artefacts'	98.3 [97.4, 99.0]	742 [712, 773]	98.7 [98.2, 99.1]	739 [720, 758]